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Brennan, III

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(54) **COMPLIANT PACKERS FOR FORMATION TESTERS**

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E21B 49/10 (2006.01)

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USPC **166/100**; 166/101; 166/250.17; 166/264; 73/152.26; 73/152.36

(58) **Field of Classification Search**
USPC 166/250.17, 264, 101, 100; 175/152.36, 175/152.17, 152.26; 73/152.36, 152.17, 152.26
See application file for complete search history.

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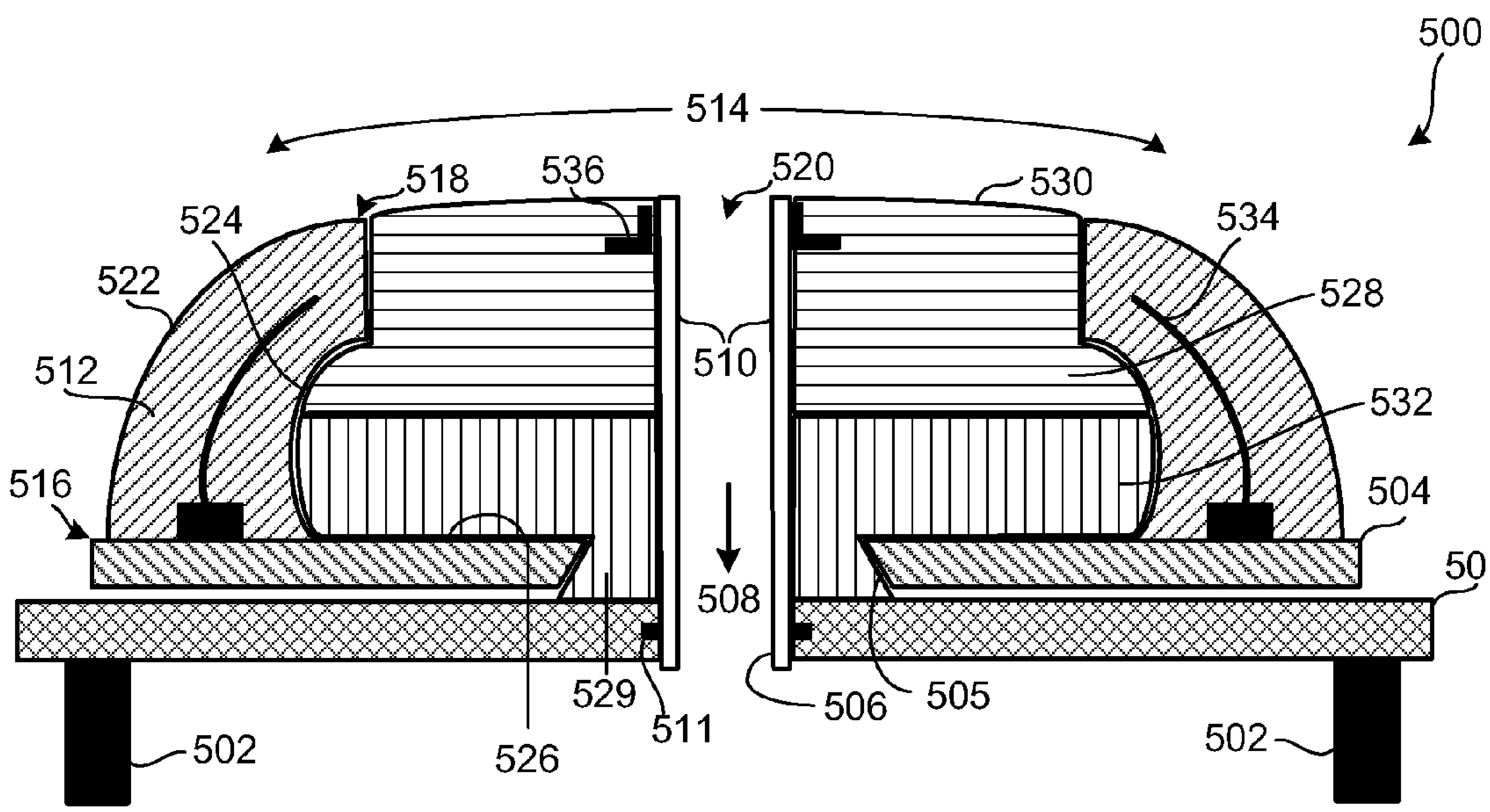
(57) **ABSTRACT**

In one embodiment, an apparatus includes a base plate having a first aperture to receive an inlet in fluid communication with a downhole tool; a compliant outer cover having a first end terminating at the base plate and a second end terminating adjacent a forward opening of the inlet, the compliant outer cover having a first surface configured to engage a borehole wall and a second surface forming an inner cavity with the base plate; and a core disposed within the inner cavity and having a second aperture forming at least a portion of the inlet, wherein the outer cover comprises a first material and the core comprises a second material more compliant than the first material.

20 Claims, 4 Drawing Sheets



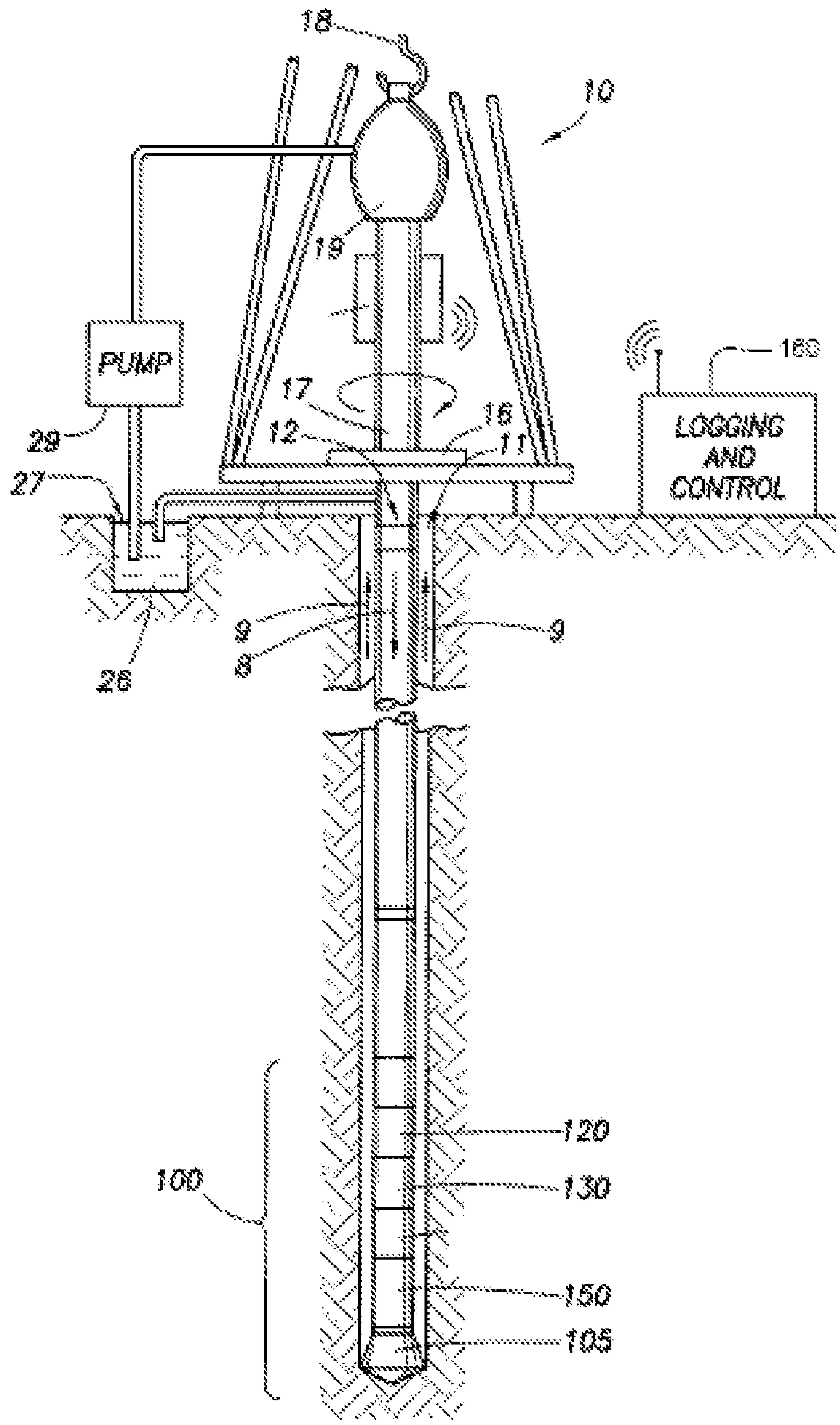

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FIG. 1

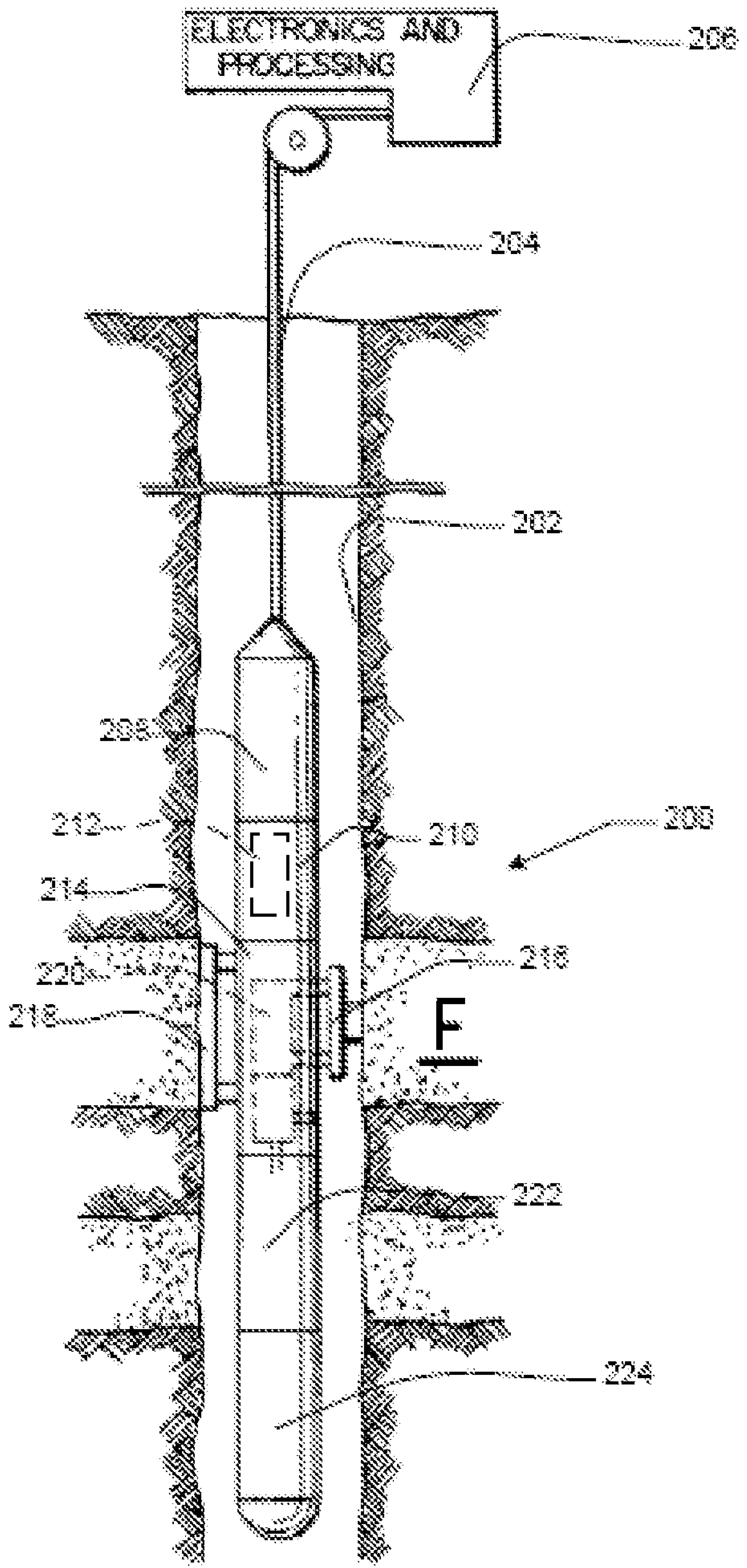
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FIG. 2

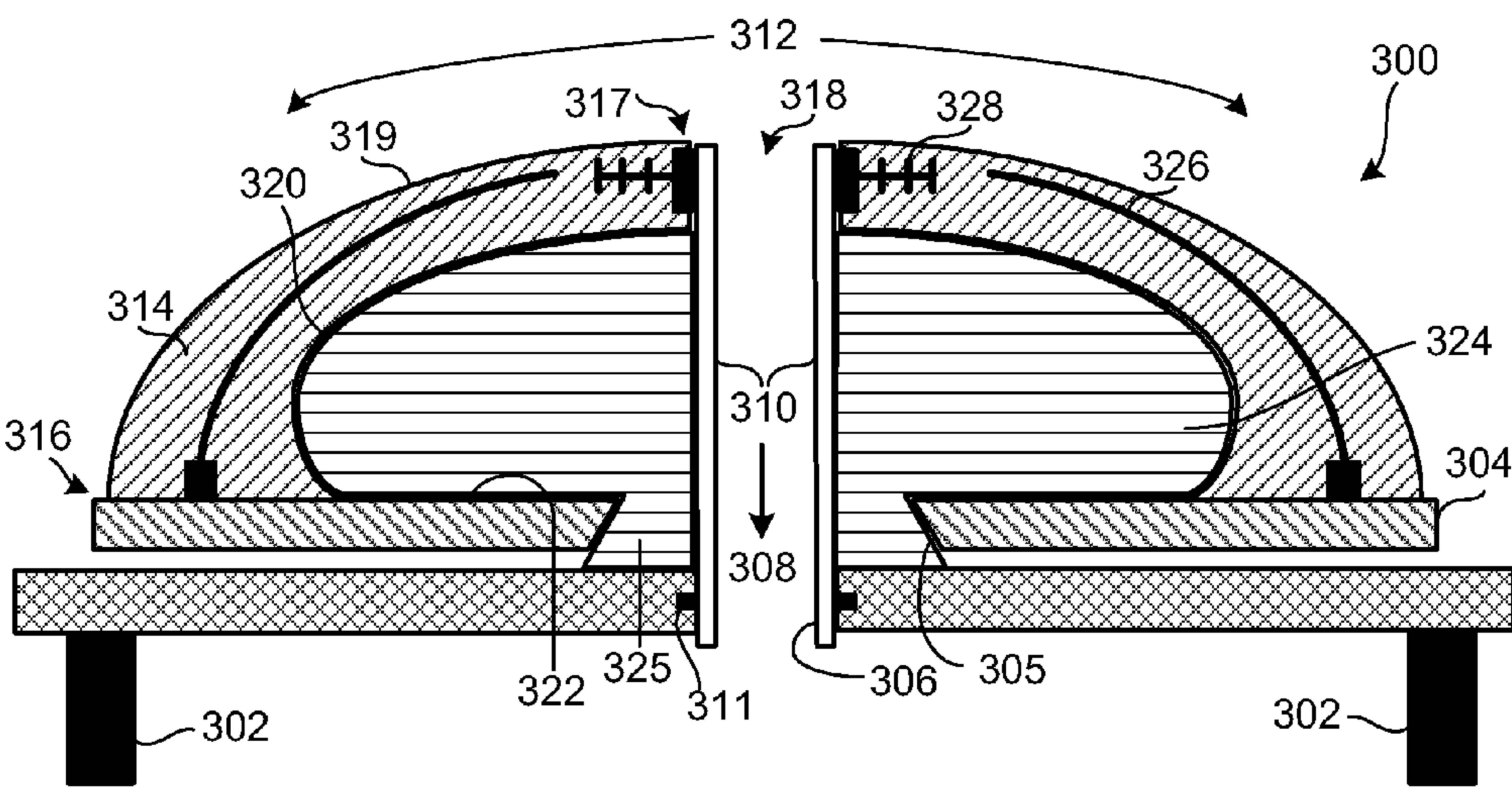
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FIG. 3

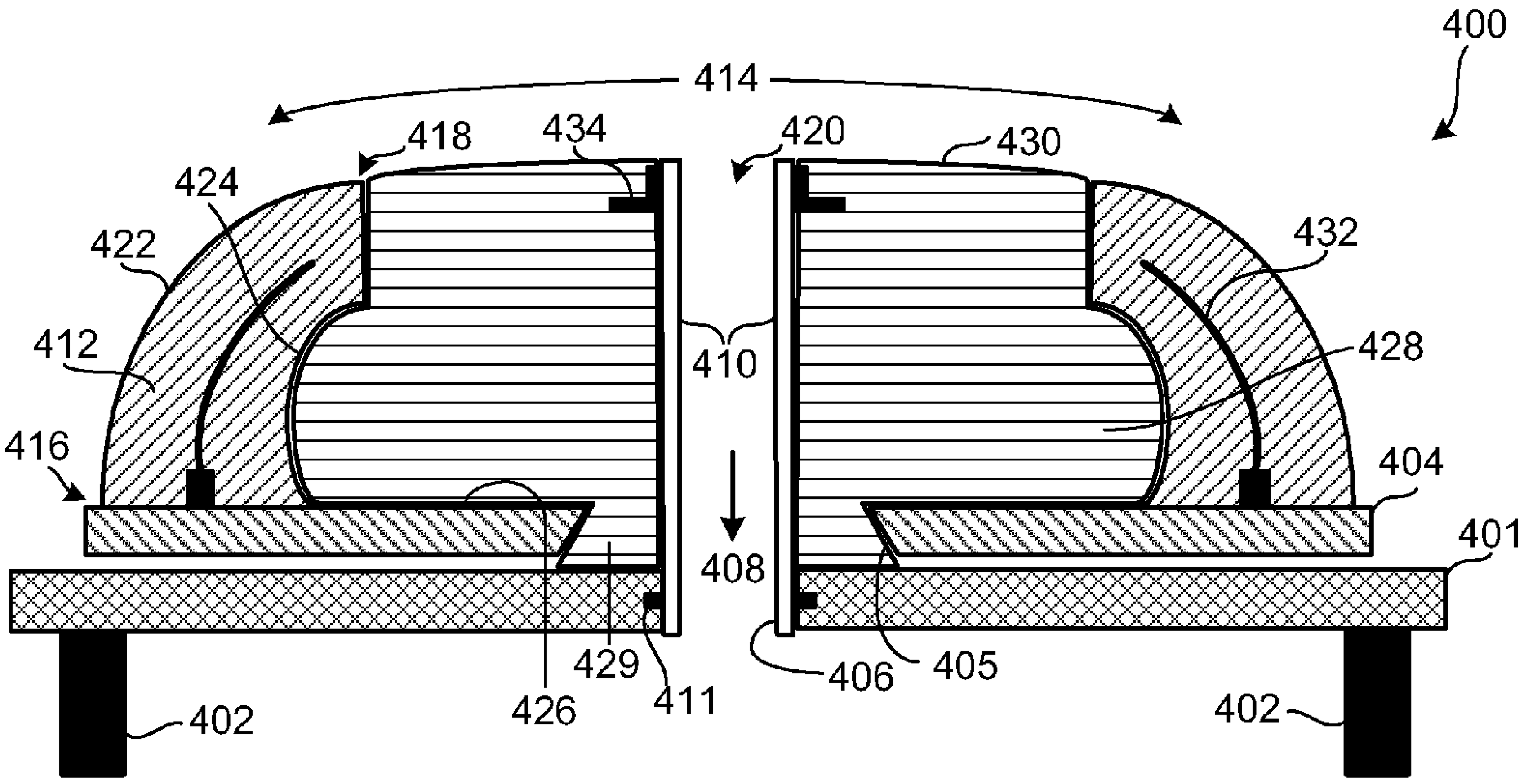
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FIG. 4

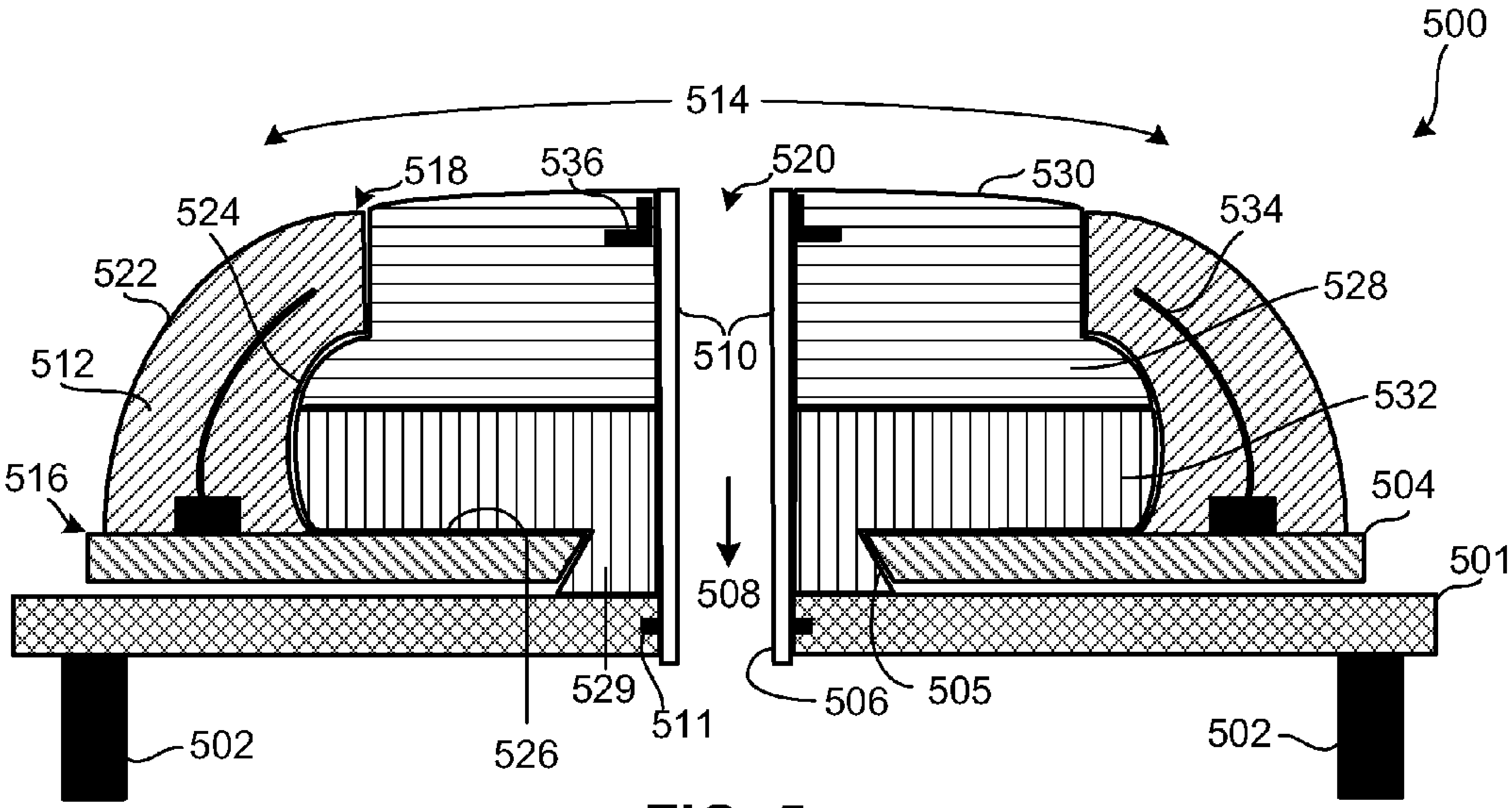
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FIG. 5

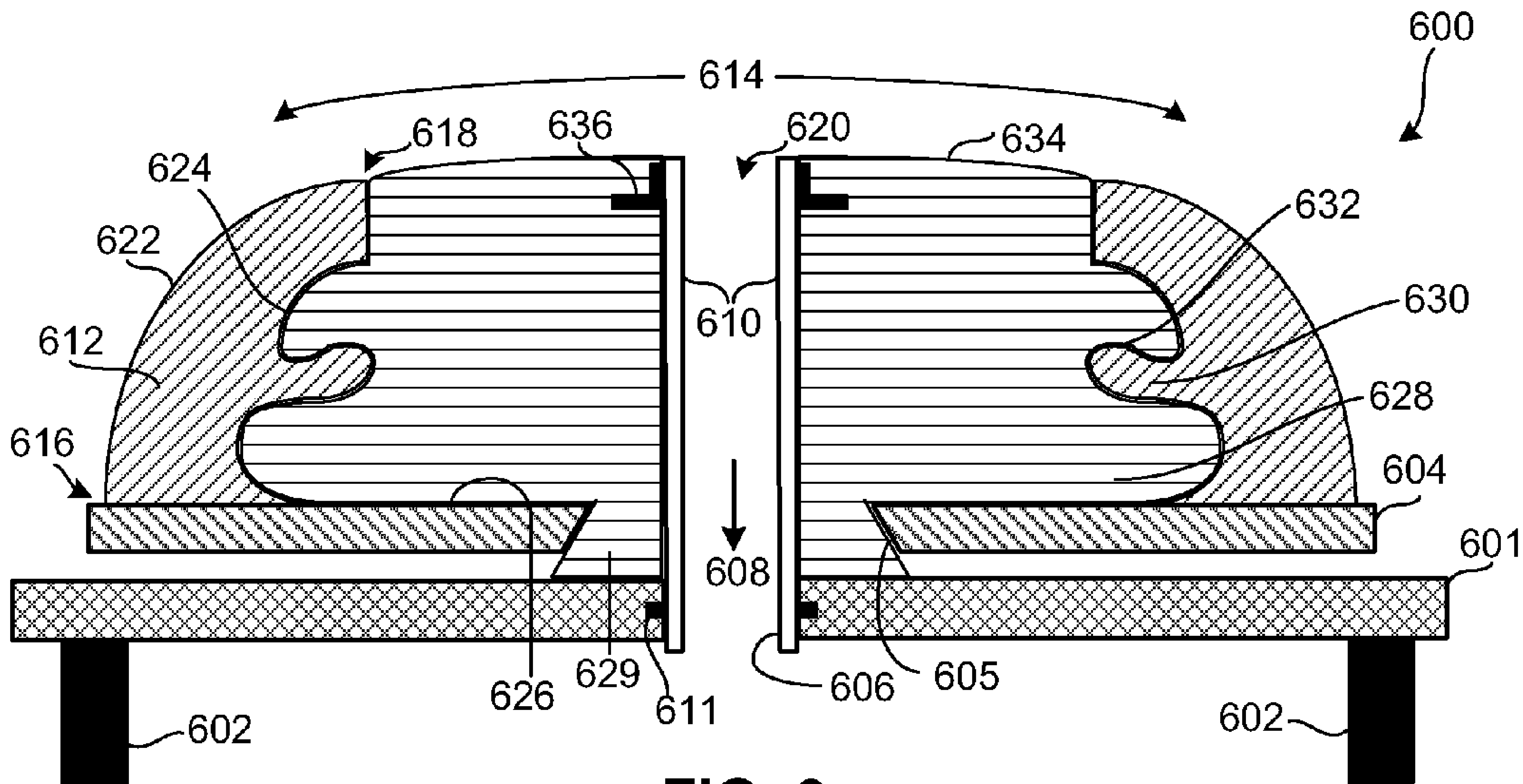
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FIG. 6

COMPLIANT PACKERS FOR FORMATION TESTERS

BACKGROUND OF THE DISCLOSURE

During a drilling operation, it may be desirable to evaluate and/or measure properties of encountered formations and formation fluids. In some cases, a drillstring is removed from a wellbore or borehole and a wireline tool is deployed into the borehole to test, evaluate and/or sample the formations and/or formation fluid(s). In other cases, the drillstring may be provided with devices to test, evaluate and/or sample the surrounding formations and/or formation fluid(s) without having to remove the drillstring from the borehole.

The formation testers of the drillstring and/or wireline tool may be used to, for example, evaluate and sample hydrocarbons extracted from a formation. Formation testers typically include a probe to gather fluid samples from the formation. A packer is often provided with the probe to create a seal against a wall of the borehole adjacent the formation. With a seal established between the borehole wall and the packer, fluid can be drawn from the formation into the formation tester.

BRIEF DESCRIPTION OF THE DRAWINGS

The present disclosure is best understood from the following detailed description when read with the accompanying figures. It is emphasized that, in accordance with the standard practice in the industry, various features are not drawn to scale. In fact, the dimensions of the various features may be arbitrarily increased or reduced for clarity of discussion.

FIG. **1** is a schematic view of apparatus according to one or more aspects of the present disclosure.

FIG. **2** is a schematic view of apparatus according to one or more aspects of the present disclosure.

FIG. **3** is a schematic view of apparatus according to one or more aspects of the present disclosure.

FIG. **4** is a schematic view of apparatus according to one or more aspects of the present disclosure.

FIG. **5** is a schematic view of apparatus according to one or more aspects of the present disclosure.

FIG. **6** is a schematic view of apparatus according to one or more aspects of the present disclosure.

DETAILED DESCRIPTION

It is to be understood that the following disclosure provides many different embodiments or examples for implementing different features of various embodiments. Specific examples of components and arrangements are described below to simplify the present disclosure. These are, of course, merely examples and are not intended to be limiting. In addition, the present disclosure may repeat reference numerals and/or letters in the various examples. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various embodiments and/or configurations discussed. Moreover, the formation of a first feature over or on a second feature in the description that follows may include embodiments in which the first and second features are formed in direct contact, and may also include embodiments in which additional features may be formed interposing the first and second features, such that the first and second features may not be in direct contact.

One or more aspects of the present disclosure relate to compliant packers for formation testers. Formation testers and the packers thereof are typically deployed in a harsh environment within boreholes. Depending on the geographic location of a borehole, the depth of deployment of the formation tester in the borehole, the size of the borehole and/or other factors, packers of the formation testers may be exposed to varying hazardous conditions. For example, a packer may be required to withstand high temperatures and/or pressure levels, both of which may adversely affect the integrity of the packer. Further, repeated and forceful contact with borehole walls may cause deterioration of the packer.

Any such loss of integrity and/or deterioration of the packer may decrease the ability of the packer to form a sufficient seal with a borehole wall and, thus, the ability of the formation tester to function properly and/or efficiently. When a packer fails to form a sufficient seal with a borehole wall, fluid samples collected by the formation tester may be contaminated with borehole fluids (e.g., drilling fluid), and/or the formation tester may be incapable of creating the necessary pressure differential to draw fluids, among other problems. Therefore, some packers are constructed with rigid materials, such as metal, capable of withstanding the harsh conditions and rugged operation experienced by a packer.

However, many borehole walls are uneven and rough. A highly rigid packer may have difficulty conforming to the topology of such a borehole wall and, therefore, may have difficulty forming a proper seal against the borehole wall. In many instances, a packer composed of a highly rigid material may be incapable of adapting or conforming to the walls of boreholes of different sizes and/or shapes. As a result, multiple differently sized packers may be needed to perform sampling operations in such differently sized and/or shaped boreholes. Furthermore, a highly rigid packer may fail to evenly distribute borehole contact forces applied to the packer and/or, more generally, the probe. As with many devices or tools, an uneven distribution of applied forces may lead to rapid deterioration or wear of certain components or portions of the device or tool. Therefore, some packers are constructed with compliant materials, such as rubber, more capable of conforming to a shape of a wellbore or borehole wall and more capable of evenly distributing contact force(s) than rigid materials.

According to one or more aspects of this disclosure, a packer may be provided with an outer shell or cover of a first compliant material forming an inner cavity. A core of a second material more compliant than the first material may be disposed within the inner cavity to support the outer shell or cover. Such a configuration enables the less compliant (i.e., more rigid) outer shell or cover to withstand the harsh conditions experienced by downhole tools and/or to provide support for the differential pressure developed during, for example, a testing operation, while simultaneously enabling the more compliant (i.e., less rigid) core to assist the packer in conforming to a profile of a wellbore or borehole wall and/or in forming a good seal therewith. A second core may also be disposed within the inner cavity to support the outer shell or cover and/or the first core. The second core may be constructed of a third material more compliant than the outer shell or cover, thereby further assisting (e.g., in conjunction with the first core) the packer in conforming to the profile of the wellbore or borehole wall. The examples described herein may include additional and/or alternative configurations and/or numbers of elements, each of which may contribute to the ability of the packer to withstand the harsh conditions of the borehole, conform to the borehole wall, provide a seal, and/or provide support for the differential pressure developed during, for example, a testing operation.

According to one or more aspects of this disclosure, a packer may be provided with an outer shell or cover of a first compliant material forming a first portion of an outer surface of the packer. A second portion of the outer surface may be formed by a first core of a second material more compliant than the first material. The more compliant first core, which may be disposed adjacent an inlet of a corresponding formation tester, enables an effective seal to be formed with a borehole wall, while the less compliant outer shell or cover enables the packer to withstand the harsh conditions of the borehole and/or to provide support for the differential pressure developed during, for example, a testing operation. A second core may also be disposed in conjunction with the outer shell or cover and the first core to further assist the packer in conforming to a profile of the borehole wall to form the seal therewith. The second core may be, for example, a bladder filled with a fluid, a solid material, and/or a semi-solid material.

FIG. **1** depicts a wellsite system including a downhole tool(s) which may be configured according to one or more aspects of the present disclosure. The wellsite drilling system of FIG. **1** can be employed onshore and/or offshore. In the example wellsite system of FIG. **1**, a borehole **11** is formed in one or more subsurface formations by rotary and/or directional drilling.

As illustrated in FIG. **1**, a drillstring **12** is suspended in the borehole **11** and includes a bottom hole assembly (BHA) **100** having a drill bit **105** at its lower end. A surface system includes a platform and derrick assembly **10** positioned over the borehole **11**. The derrick assembly **10** includes a rotary table **16**, a kelly **17**, a hook **18** and a rotary swivel **19**. The drillstring **12** is rotated by the rotary table **16**, energized by means not shown, which engages the kelly **17** at an upper end of the drillstring **12**. The example drillstring **12** is suspended from the hook **18**, which is attached to a traveling block (not shown), and through the kelly **17** and the rotary swivel **19**, which permits rotation of the drillstring **12** relative to the hook **18**. Additionally or alternatively, a top drive system could be used.

In the example depicted in FIG. **1**, the surface system further includes drilling fluid **26**, which is commonly referred to in the industry as "mud," and which is stored in a pit **27** formed at the well site. A pump **29** delivers the drilling fluid **26** to the interior of the drillstring **12** via a port in the rotary swivel **19**, causing the drilling fluid **26** to flow downwardly through the drillstring **12** as indicated by the directional arrow **8**. The drilling fluid **26** exits the drillstring **12** via ports in the drill bit **105**, and then circulates upwardly through the annulus region between the outside of the drillstring **12** and the wall of the borehole **11**, as indicated by the directional arrows **9**. The drilling fluid **26** lubricates the drill bit **105**, carries formation cuttings up to the surface as it is returned to the pit **27** for recirculation, and creates a mudcake layer (not shown) on the walls of the borehole **11**.

The example bottom hole assembly **100** of FIG. **1** includes, among other things, any number and/or type(s) of logging-while-drilling (LWD) modules or tools (one of which is designated by reference numeral **120**) and/or measuring-while-drilling (MWD) modules (one of which is designated by reference numeral **130**), a rotary-steerable system or mud motor **150** and the example drill bit **105**. The MWD module **130** measures the drill bit **105** azimuth and inclination that may be used to monitor the borehole trajectory.

The example LWD tool **120** and/or the example MWD module **130** of FIG. **1** may be housed in a special type of drill collar, as it is known in the art, and contains any number of logging tools and/or fluid sampling devices. The example LWD tool **120** includes capabilities for measuring, processing and/or storing information, as well as for communicating with the MWD module **130** and/or directly with the surface equipment, such as, for example, a logging and control computer **160**.

The logging and control computer **160** may include a user interface that enables parameters to be input and or outputs to be displayed that may be associated with the drilling operation and/or the formation traversed by the borehole **11**. While the logging and control computer **160** is depicted uphole and adjacent the wellsite system, a portion or all of the logging and control computer **160** may be positioned in the bottom hole assembly **100** and/or in a remote location.

FIG. **2** depicts an example wireline system including a downhole tool(s) that may be configured according to one or more aspects of the present disclosure. The example wireline tool **200** may be used to extract and analyze formation fluid samples and is suspended in a borehole or wellbore **202** from the lower end of a multiconductor cable **204** that is spooled on a winch (not shown) at the surface. At the surface, the cable **204** is communicatively coupled to an electrical control and data acquisition system **206**. The tool **200** has an elongated body **208** that includes a housing **210** having a tool control system **212** configured to control extraction of formation fluid from a formation F and measurements performed on the extracted fluid.

The wireline tool **200** also includes a formation tester **214** having a selectively extendable fluid admitting assembly **216** (which is also commonly referred to as a probe assembly) and a selectively extendable tool anchoring member **218** that are respectively arranged on opposite sides of the body **208**. The fluid admitting assembly **216** is configured to selectively seal off or isolate selected portions of the wall of the wellbore **202** to fluidly couple to the adjacent formation F and draw fluid samples from the formation F. The formation tester **214** also includes a fluid analysis module **220** through which the obtained fluid samples flow. The fluid may thereafter be expelled through a port (not shown) or it may be sent to one or more fluid collecting chambers **222** and **224**, which may receive and retain the formation fluid for subsequent testing at the surface or a testing facility.

In the illustrated example, the electrical control and data acquisition system **206** and/or the downhole control system **212** are configured to control the fluid admitting assembly **216** to draw fluid samples from the formation F and to control the fluid analysis module **220** to measure the fluid samples. In some example implementations, the fluid analysis module **220** may be configured to analyze the measurement data of the fluid samples as described herein. In other example implementations, the fluid analysis module **220** may be configured to generate and store the measurement data and subsequently communicate the measurement data to the surface for analysis at the surface. Although the downhole control system **212** is shown as being implemented separate from the formation tester **214**, in some example implementations, the downhole control system **212** may be implemented in the formation tester **214**.

The formation tester **214** of FIG. **2**, which may also be deployed on the example drillstring **12** of FIG. **1**, may utilize the example methods and apparatus described herein. While the example apparatus and methods described herein are described in the context of drillstrings and/or wireline tools, they are also applicable to any number and/or type(s) of additional and/or alternative downhole tools such as coiled tubing deployed tools. Further, one or more aspects of this disclosure may also be used in other coring applications such as side-wall and/or in-line coring.

FIG. **3** is schematic cross-sectional view of a first example packer **300** configured according to one or more aspects of the present disclosure. The packer **300** may be implemented in association with, for example, the formation tester **214** of FIG. **2** and/or the drillstring **12** of FIG. **1**. In particular, the packer **300** of FIG. **3** may be mechanically coupled to the formation tester **214** (not shown in FIG. **3**) via a probe shoe **301** coupled to first and second positioning pistons **302**. A base plate **304** of the packer **300** is mounted to the probe shoe **301**. The positioning pistons **302** may be actuated to extend the probe shoe **301** and, therefore, the packer **300** toward a formation to be tested. As described in detail below, the packer **300** forms a seal against the formation and against the probe shoe **301** when forced against a wall of a borehole.

The base plate **304** includes a central aperture **305** to define an inlet **306** through which formation fluid may be drawn in a direction indicated by arrow **308**. During formation testing procedures, and/or during drawing sample fluid into the formation tester **214**, a probe barrel **310** is extended through the inlet **306**. The probe barrel **310** is disposed within the inlet **306** and may be configured to provide an interference fit with the walls of the inlet **306**. The probe barrel **310** may be retractable and extendable along the inlet **306** to make selective contact with a borehole wall and/or to penetrate mud cake lining the borehole wall. The probe barrel **310** may include a screen (not shown) to filter contaminants as formation fluid enters the formation tester **214** via the inlet **306**. Furthermore, the probe barrel **310** may be configured to engage and penetrate one or more layers of the borehole wall using one or more protrusions or teeth (not shown) to ensure fluid coupling beyond a damaged portion of a formation adjacent the location of the formation tester. When the probe barrel **310** is retracted into, for example, a travel position, the probe barrel **310** may be recessed relative to an outer surface **312** of the packer **300**. Additionally, the probe barrel **310** engages a seal **311**, such as an O-ring, as it passes through the probe shoe **301**.

Generally, the formation tester **214** forces (e.g., using one or more pistons) the outer surface **312** of the packer **300** against a borehole wall to form a seal therewith. The outer surface **312** is curved to contact normally cylindrical walls of wellbores. With the seal established between the borehole wall and the packer **300**, the probe barrel **310** may channel formation fluid through the inlet **306** into the formation tester **214**. To draw the fluid through the inlet **306**, the formation tester **214** creates a pressure differential that applies a strain on the seal. To withstand this strain and for additional reasons discussed above (e.g., harsh environmental conditions such as high temperatures, wear from repeated contact and applied forces, etc.), the packer **300** is configured as shown in FIG. **3**.

For example, the packer **300** includes an outer cover **314** extending from the base plate **304**. The outer cover **314** may comprise a shell. The outer cover **314** of FIG. **3** has a first end **316** terminating at the base plate **304** and a second end **317** terminating adjacent a forward opening **318** of the inlet **306**. Therefore, in the illustrated example of FIG. **3**, the outer cover **314** forms substantially the entire outer surface **312** of the packer **300**. The outer cover **314** has an outer surface **319** and an inner surface **320**. The inner surface **320** forms an inner cavity **322** with the base plate **304** and the probe barrel **310**.

The packer **300** also includes a core **324** disposed within the inner cavity **322** formed by the inner surface **320** of the outer cover **314**, the base plate **304**, and the probe barrel **310**. The core **324** includes a portion **325** extending through the aperture **305** of the base plate **304** to engage the probe shoe **301**. This portion **325** forms a seal against the probe shoe **301** when the packer **300** is forced against a borehole wall. In the illustrated example of FIG. **3**, the core **324** is a single, solid material molded in the shape of the inner cavity **322**. However, in some example implementations, the core **324** may be a bladder filled with, for example, oil, gel, and/or some other fluid or semi-solid material. Alternatively, the core **324** may be molded first and the outer cover **314** may be molded to conform to the shape of the core **324**. The outer cover **314** and the core **324** may or may not be bonded together. Regardless of the order of molding (or other construction aspects), the outer cover **314** and the core **324** are configured such that the core **324** is disposed within the inner cavity **322** formed in part by the outer cover **314**. This configuration enables the core **324** to support the outer cover **314** when, for example, the outer surface **312** of the packer **300** is forced against a borehole wall, thereby compressing or displacing the outer cover **314**.

The core **324** of FIG. **3** is constructed of a first material having a first compliance and the example outer cover **314** of FIG. **3** is constructed of a second material having a second compliance. In the illustrated example, the second material of the outer cover **314** is less compliant (i.e., has a higher rigidity) than the first material of the core **324**. Accordingly, the outer cover **314** is better suited to withstand direct exposure to the harsh conditions experienced by the outer surface **312** of the packer **300**. The material of the outer cover **314** is selected to maintain its physical properties while exposed to downhole temperatures and stresses caused by contact pressure. For example, the material of the outer cover **314** may be selected to provide a relatively low amount of deterioration due to abrasive contact with different surfaces, such as those associated with a borehole wall. However, at the same time, the material of the outer cover **314** may also be selected to remain sufficiently compliant under downhole conditions to enable the packer **300** to conform to a profile of the borehole wall against which a seal is to be formed. On the other hand, the material of the core **324** is selected to maintain its compliance when exposed to the downhole temperatures. In the example of FIG. **3**, the core **324** does not contact the borehole wall and, thus, does not have to withstand abrasive contact with the borehole wall.

To facilitate the application and/or the evenly distribution of sealing pressure against the borehole wall, the relatively more compliant core **324** supports the outer cover **314** in response to a compression or displacement of the outer cover **314**. The core **324** is capable of providing the packer **300** with a greater degree of compliance and, thus, an ability to adapt to different sized boreholes and to enable the packer **300** to form a good seal against a variety of different boreholes. Without such ability, additional packers of different sizes and/or shapes may be required to adapt to differently sized boreholes.

Thus, the packer configuration illustrated in FIG. **3** enables the packer **300** to employ a compliant outer cover **314** to form a seal with a borehole wall by supporting the outer cover **314** with the core **324** composed of the second, relatively more compliant material (in comparison to the first material of the outer cover **314**). In this manner, the less compliant outer cover **314** can provide a material strength necessary to, for example, sustain the pressure differential created by the draw of fluid by the formation tester **214** and to withstand harsh wellbore conditions (e.g., abrasive contact with the borehole wall), while the more compliant core **324** can provide a greater compliance to enable the packer **300** to conform to the shape of the borehole wall.

To provide additional support to the packer **300** (e.g., by carrying an amount of force applied to the outer surface **312** of the cover **314**), the outer cover **314** may include a reinforcement structure **326** disposed between the outer and inner surfaces **319** and **320** of the outer cover **314**. The reinforcement structure **326** may be, for example, a metal rib extending from the base plate **304** (as shown in FIG. **3**), metal rings, wire rings, wire cable, fiber cable, loose fiber, and/or any other material. Additionally, to provide support for the packer **300** at the highly stressed areas of the outer cover **314** adjacent the forward opening **318** of the inlet **306**, the example packer **300** may include an insert **328** constructed of, for example, metal. The example insert **328** shown in FIG. **3** surrounds the forward opening **318** of the inlet **306**, reducing the material strength required in that area and, thereby enabling the outer cover **314** to operate similar to an O-ring in creating the seal as described herein.

FIG. **4** is schematic cross-sectional view of a second example packer **400** configured according to one or more aspects of the present disclosure. The packer **400** may be implemented in association with, for example, the formation tester **214** of FIG. **2** and/or the drillstring **12** of FIG. **1**. The packer **400** of FIG. **4** is mechanically coupled to the formation tester **214** via a probe shoe **401** coupled to first and second positioning pistons **402**. A base plate **404** is mounted to the probe shoe **401**. The base plate has an aperture **405** to define an inlet **406** through which sample formation fluid may be drawn in the direction of the arrow **408**. The example packer **400** of FIG. **4** also includes a probe barrel **410** and a seal **411**. For purposes of brevity and not limitation, certain aspects and/or operations of the packer **400**, such as the probe shoe **401**, the first and second positioning pistons **402**, the base plate **404**, the inlet **406**, and the probe barrel **410**, are not described in detail in connection with FIG. **4**, as these aspects and/or operations are described in connection with other FIGURES of the present disclosure, for example in connection with FIG. **3**.

The packer **400** of FIG. **4** includes an outer cover **412** extending from the base plate **404** to form a first portion of an outer surface **414** of the packer **400**. The outer cover **412** has a first end **416** terminating at the base plate **404** and a second end **418** terminating at a point along the outer surface **414** between the base plate **404** and a forward opening **420** of the inlet **406**. The outer cover **412** has an outer surface **422** and an inner surface **424**. The inner surface **424** forms an interior space **426** with the base plate **404** and the probe barrel **410**. The outer cover **412** is constructed of a first material having a first compliance, for example similar to the outer cover **314** of FIG. **3**. The outer cover **412** may form at least a portion of the sealing surface with the borehole wall. Therefore, the material of the outer cover **412** is compliant enough to conform to a borehole wall but also rigid enough to meet high temperature requirements and to reduce the amount of deterioration that may result from abrasive contact with different surfaces, such as those of a borehole wall.

The packer **400** of FIG. **4** also includes a core **428** disposed within the interior space **426** defined by the inner surface **424** of the outer cover **412**, the base plate **404**, and the probe barrel **410**. The core **428** includes a portion **429** extending through the aperture **405** of the base plate **404** to engage the probe shoe **401**. This portion **429** forms a seal against the probe shoe **401** when the packer **400** is forced against a borehole wall. The example core **428** is constructed of a second material having a second compliance greater than the compliance of the outer cover **412**. As the core **428** of FIG. **4** is exposed to well fluids and makes contact with the formation to be tested, the example core **428** of FIG. **4** may be less compliant than the core **324** of FIG. **3** and better able to withstand adverse chemical effects of the well fluids. In the illustrated example of FIG. **4**, the core **428** is a single, solid material molded in the shape of the interior space **426**. However, as described above in connection with FIG. **3**, the outer cover **412** may alternatively be molded in the shape of the core **428**. In other words, the order of construction operations is interchangeable.

In the example of FIG. **4**, an outer surface **430** of the core **428** forms a second portion of the outer surface **414** of the packer **400**, while the outer cover **412** forms the first portion of the outer surface **414**. In particular, the second portion of the outer surface **414** formed by the outer surface **430** of the core **428** surrounds the forward opening **420** of the inlet **406**. Therefore, the seal formed with the borehole wall is formed primarily by the more compliant core **428** (in comparison with the outer cover **412**) and secondarily (if at all) by the less compliant outer cover **412** (in comparison with the core **428**). As described above, material properties that are suitable to maintain mechanical integrity at higher temperatures may differ from the material properties that are suitable to form a seal. The configuration of the packer **400** of FIG. **4** enables the outer cover **412** to maintain the mechanical integrity of the packer **400** under the stress of the wellbore environment, while the core **428** can provide the necessary compliance at the point of sealing. Thus, the packer **400** is configured to conform to boreholes of varying sizes and shapes to form a seal and also to maintain the seal despite the harsh conditions of a wellbore (e.g., deterioration and/or breakdowns of seal integrity due to high temperatures and/or repeated impacts).

Similar to the packer **300** of FIG. **3**, the packer **400** of FIG. **4** may include a reinforcement structure **432** (e.g., a metal rib extending from the base plate **404** (as shown in FIG. **4**), metal rings, wire rings, wire cable, fiber cable, loose fiber, and/or any other material) disposed between the outer and inner surfaces **422** and **424** of the outer cover **412**. Additionally, the example packer **400** may include an insert **434** constructed of, for example, metal to provide support for the packer **400** at the highly stressed areas of the outer surface **414** adjacent the forward opening **420** of the inlet **406**.

FIG. **5** is schematic cross-sectional view of a third example packer **500** configured according to one or more aspects of the present disclosure. The packer **500** may be implemented in association with, for example, the formation tester **214** of FIG. **2** and/or the drillstring **12** of FIG. **1**. The packer **500** of FIG. **5** is mechanically coupled to the formation tester **214** via a probe shoe **501** coupled to first and second positioning pistons **502**. A base plate **504** is mounted to the probe shoe **501**. The base plate **504** has an aperture **505** to define an inlet **506** through which sample formation fluid may be drawn in the direction of arrow **508**. The packer **500** also includes a probe barrel **510** and a seal **511**. For purposes of brevity and not limitation, certain aspects and/or operations of the probe shoe **501**, the first and second positioning pistons **502**, the base plate **504**, the inlet **506**, and the probe barrel **510** of FIG. **5** are not described in detail in connection with FIG. **5**, as these aspects and/or operations are described herein in connection with other FIGURES, for example in connection with FIG. **3**.

The packer **500** includes an outer cover **512** extending from the base plate **504** to form a first portion of an outer surface **514** of the packer **500**. The outer cover **512** has a first end **516** terminating at the base plate **504** and a second end **518** terminating at a point along the outer surface **514** between the base plate **504** and a forward opening **520** of the inlet **506**. The outer cover **512** has an outer surface **522** and an inner surface **524**. The inner surface **524** forms an interior space **526** with the base plate **504** and the probe barrel **510**. The outer cover **512** is constructed of a first material having a first compliance similar to the outer cover **314** of FIG. **3**. As described above in connection with FIG. **3**, the material of the outer cover **512** can meet high temperature requirements and can reduce the amount of deterioration that may result from abrasive contact with different surfaces, such as those associated with a borehole wall.

The packer **500** also includes a forward core **528** disposed within a forward portion of the interior space **526**. The forward core **528** is constructed of a second material having a second compliance greater than the compliance of the outer cover **512**. As the core **528** is exposed to well fluids and makes contact with the formation to be tested, the core **528** of FIG. **5** may be less compliant than the core **324** of the packer **300** of FIG. **3** and better able to withstand adverse chemical effects of the well fluids. In the illustrated example of FIG. **5**, the forward core **528** is a single, solid material molded in the shape of the forward portion of the interior space **526**.

In the example of FIG. **5**, an outer surface **530** of the forward core **528** forms a second portion of the outer surface **514** of the packer **500**, while the outer cover **512** forms the first portion of the outer surface **514**. In particular, the second portion of the outer surface **514** formed by the outer surface **530** of the forward core **528** surrounds the forward opening **520** of the inlet **506**. Therefore, the seal formed with the borehole wall is formed primarily by the more compliant forward core **528** (in comparison with the outer cover **512**) and secondarily (if at all) by the less compliant outer cover **512** (in comparison with the forward core **528**). As described above, material properties that are suitable to maintain mechanical integrity at higher temperatures may differ from the material properties that are suitable to form a seal. The configuration of the packer **500** of FIG. **5** enables the outer cover **512** to maintain the mechanical integrity of the packer **500** under the stress of the wellbore environment, while the forward core **528** can provide the necessary compliance at the point of sealing. Thus, the packer **500** is configured to conform to boreholes of varying sizes and shapes to form a seal, and also to maintain the seal despite the harsh conditions of a wellbore (e.g., deterioration and/or breakdowns of integrity due to high temperatures and/or repeated impacts).

The packer **500** of FIG. **5** also includes a rearward core **532** disposed within a rearward portion of the interior space **526**. The rearward core **532** includes a portion **529** extending through the aperture **505** of the base plate **504** to engage the probe shoe **501**. This portion **529** forms a seal against the probe shoe **501** when the packer **500** is forced against a borehole wall. In the illustrated example of FIG. **5**, the rearward core **532** is constructed of a third material having a third compliance greater than the compliance of the forward core **528**. For example, the rearward core **528** may be a bladder that can be filled with, for example, oil, gel, any type of fluid, and/or a semi-solid material. Alternatively, the rearward core **532** may be a solid molded material.

In operation, when a force is applied to the outer surface **514** of the packer **500** (e.g., by the formation tester **214** pressing the packer **500** against a wellbore wall), the forward core **528** compresses and, in turn, applies a force to the rearward core **532**. Thus, the rearward core **532** supports the forward core **528** as the forward core **528** forms a seal with a borehole wall. The outer cover **512** restricts the forward core **528** and the rearward core **532** from peripherally displacing, which may adversely affect the seal made by the forward core **528**. The rearward core **532** being constructed of a highly compliant material (e.g., a gel-filled bladder) enables the forward core **528** to be constructed of a more rigid (yet still compliant enough to conform to a borehole profile) material than, for example, the core **428** of the packer **400** of FIG. **4**.

Similar to the packer **300** of FIG. **3**, the packer **500** of FIG. **5** may include a reinforcement structure **534** (e.g., a metal rib extending from the base plate **504** (as shown in FIG. **5**), metal rings, wire rings, wire cable, fiber cable, loose fiber, and/or any other material) disposed between the outer and inner surfaces **522** and **524** of the outer cover **512**. Additionally, the packer **500** may include an insert **536** constructed of, for example, metal to provide support for the packer **500** at the highly stressed areas of the outer surface **514** adjacent the forward opening **520** of the inlet **506**.

FIG. **6** is schematic cross-sectional view of a fourth example packer **600** configured according to one or more aspects of the present disclosure. The packer **600** may be implemented in association with, for example, the formation tester **214** of FIG. **2** and/or the drillstring **12** of FIG. **1**. The packer **600** of FIG. **6** is mechanically coupled to the formation tester **214** via a probe shoe **601** coupled to first and second positioning pistons **602**. A base plate **604** is mounted to the probe shoe **601**. The base plate **604** has an aperture **605** to define an inlet **606** through which sample formation fluid may be drawn in the direction of the arrow **608**. The packer **600** of FIG. **6** also includes a probe barrel **610** and a seal **611**. For purposes of brevity and not limitation, certain aspects and/or operations of the probe shoe **601**, the first and second positioning pistons **602**, the base plate **604**, the inlet **606**, and the probe barrel **610** of FIG. **6** are not described in detail in connection with FIG. **6**, as these aspects and/or operations are described above in connection with FIG. **3**.

The packer **600** includes an outer cover **612** extending from the base plate **604** to form a first portion of an outer surface **614** of the packer **600**. The outer cover **612** of FIG. **6** has a first end **616** terminating at the base plate **604** and a second end **618** terminating at a point along the outer surface **614** between the base plate **604** and a forward opening **620** of the inlet **606**. The outer cover **612** has an outer surface **622** and an inner surface **624**. The inner surface **624** forms an interior space **626** with the base plate **604** and the probe barrel **610**. The outer cover **612** is constructed of a first material having, for example, a compliance similar to the outer cover **314** of FIG. **3**. As described above in connection with FIG. **3**, the outer cover **612** of the first material can meet high temperature requirements and can reduce the amount of deterioration resulting from abrasive contact with different surfaces, such as the borehole wall.

The packer **600** also includes a core **628** disposed within the interior space **626** defined by the inner surface **624** of the outer cover, the base plate **604**, and the probe barrel **610**. The core **628** includes a portion **629** extending through the aperture **605** of the base plate **64** to engage the probe shoe **601**. This portion **629** forms a seal against the probe shoe **601** when the packer **600** is forced against a borehole wall. The example core **628** is constructed of a second material having a compliance greater than the compliance of the outer cover **612**. As the core **628** is exposed to well fluids and makes contact with the formation to be tested, the core **628** may be less compliant than the core **324** of the example packer **300** of FIG. **3** and better able to withstand adverse chemical effects of the well fluids. In the illustrated example of FIG. **6**, the core **628** is a single, solid material molded in the shape of the interior space **626**. However, as described above in connection with FIG. **3**, the outer cover **612** may alternatively be molded in the shape of the core **628**. In other words, the order of construction operations is interchangeable.

In the illustrated example of FIG. **6**, the inner surface **624** of the outer cover **612** includes a protrusion **630** configured to act as an interlocking structure. In particular, the protrusion **630**, which extends inwardly from the inner surface **624** of the outer cover **612**, is configured to be received by a corresponding mating feature **632** of the core **628**. Thus, the protrusion **630** and the mating feature **632** cooperate to interlock the outer cover **612** and the core **628**. In the illustrated example of FIG. **6**, in which the core **628** and the outer cover **612** are solid, molded pieces, each of the core **628** and the outer cover **612** can be molded in any order and assembled in any manner. Additional or alternative configurations of protrusion and corresponding mating feature(s) can be optimized for particular stresses to be experienced by additional or alternative packers.

In addition to or instead of the interlocking features **630** and **632** of FIG. **6**, the example packers **300**, **400**, **500**, and/or **600** of FIGS. **3-6** described herein may include reinforcement structures that bridge between the outer cover and the core thereof. For example, the reinforcement structure **326** of the example packer **300** of FIG. **3** may bridge between the core **324** and the outer cover **314** such that the core **324** and the outer cover **314** are interlocked. The other example packers described herein can be similarly configured to ensure maintenance of the structural relationship between the core(s) and the covers or shells.

Referring back to FIG. **6**, an outer surface **634** of the core **628** forms a second portion of the outer surface **614** of the packer **600**, while the outer cover **612** forms the first portion of the outer surface **614**. In particular, the second portion of the outer surface **614** formed by the outer surface **634** of the core **628** surrounds the forward opening **620** of the inlet **606**. Therefore, the seal formed with the wellbore wall is formed primarily by the more compliant core **628** (in comparison with the outer cover **612**) and secondarily (if at all) by the less compliant outer cover **612** (in comparison with the core **628**). The configuration of the packer **600** enables the outer cover **612** to maintain the mechanical integrity under the stress of the wellbore environment, while the core **628** can provide the necessary compliance at the point of sealing. Thus, the packer **600** is configured to conform to boreholes of varying sizes and shapes to form a seal and also to maintain the seal despite the harsh conditions of a wellbore (e.g., deterioration and/or breakdowns of integrity due to high temperatures and/or pressures).

Similar to the packer **300** of FIG. **3**, the example packer **600** of FIG. **6** may include an insert **636** constructed of, for example, metal to provide support for the packer **600** at the highly stressed areas of the outer surface **614** adjacent the forward opening **620** of the inlet **606**.

With respect to the example packers **300**, **400**, **500** and **600** of FIGS. **3-6**, an example of the least compliant material is an HNBR 85 durometer material, such as the Maloney compound **8009**. The more compliant core could be the same type of material, but in a formulation with 65 durometer. The 65 durometer material is much more compliant but not as strong as the 85 durometer material. Another example of the material for the inner core is DuPont Viton Extreme with 75 durometer. For example, in FIG. **4**, this material may be used to form the core **428**, with the 85 durometer HNBR Maloney compound **8009** forming the outer cover **412**. Silicon oil in a bladder of Extreme Viton is one possible material combination for a very fluid inner core. In an exemplary embodiment of the packer **500** shown in FIG. **5**, the outer cover **512** is composed of about 85 durometer material and at least one of the first and second cores **528**, **532** is composed of about 65 durometer material. In another example, the outer cover **512** is composed of about 85 durometer material, the first core **528** is composed of about 75 durometer material, and the second core **532** is composed of about 65 durometer material. In other examples of the packers shown in FIGS. **3-6**, the outer cover is composed of a first material that is greater than about 80 durometer material and the one or more cores are composed of a second material that is less than about 70 durometer material. However, the material options described above are merely examples, and other materials are also within the scope of the present application.

In view of the foregoing description and the figures, it should be clear that the present disclosure introduces an apparatus comprising a base plate having a first aperture to receive an inlet in fluid communication with a downhole tool; a shell extending from a peripheral portion of the base plate and having a first surface forming a first portion of an outer surface of a packer and configured to engage a wellbore or borehole wall and a second surface forming an inner cavity with the base plate; a first core having a first surface forming a second portion of the outer surface of the packer and configured to engage the wellbore or borehole wall, a second surface to engage the second surface of the shell forming the inner cavity, and a third surface to engage a first portion of the inlet; and a second core disposed between the first core and the base plate, the second core having a first surface to engage the second surface of the shell forming the inner cavity and a second surface to engage a second portion of the inlet. The shell may comprise a first material, the first core may comprise a second material, the second core may comprise a third material, and the second and third materials may be more compliant than the first material. The first core may comprise a sealing material and the second core may comprise a bladder. The apparatus may further comprise one or more reinforcement strands disposed between the first and second surfaces of the shell. The first core may prevent the second core from contacting the wellbore wall. The downhole tool may be configured for conveyance in a borehole via at least one of a wireline or a drillstring.

The present disclosure also introduces an apparatus comprising a base plate having a first aperture to receive an inlet in fluid communication with a downhole tool; a compliant outer cover having a first end terminating at the base plate and a second end terminating at an opening of the inlet, the compliant outer cover having a first surface configured to engage a wellbore or borehole wall and a second surface forming an inner cavity with the base plate; and a core disposed within the inner cavity and having a second aperture forming at least a portion of the inlet, wherein the outer cover comprises a first material and the core comprises a second material more compliant than the first material. The compliant outer cover may comprise an entire outer surface of a packer to prevent the core from contacting the wellbore or borehole wall. The core may abut the second surface of the compliant outer cover, the base plate and a probe barrel defining the inlet. A first surface of the core may have a curvature substantially similar to a curvature of the second surface of the compliant outer cover. The apparatus may further comprise a support disposed between the first and second surfaces of the compliant outer cover. The support may comprise at least one of a rib or a reinforcing strand. The core may comprise a bladder that may be configured to take a shape of the inner cavity when the bladder is filled. The apparatus may further comprise a second core to be inserted into the inner cavity comprising a third material more compliant than the first material of the outer cover. The apparatus may further comprise a metal insert in the compliant outer cover disposed between the first and second surfaces of the compliant outer cover and adjacent the forward opening of the inlet. The core may be composed of a solid material. The downhole tool may be configured for conveyance in a borehole via at least one of a wireline or a drillstring.

The present disclosure also introduces a method of establishing fluid communication between a downhole tool and a formation, the method comprising extending a packer from the downhole tool against a wellbore or borehole wall; and forming a seal between the wellbore or borehole wall and the packer, an outer surface of the packer being formed by a compliant outer cover having a first end terminating at a base plate and a second end terminating at an opening of an inlet, the outer cover having an inner surface forming an inner cavity with the base plate, wherein a core having an aperture forming at least a portion of the inlet is disposed within the inner cavity, and wherein the outer cover comprises a first material and the core comprises a second material more compliant than the first material. The method may further comprise drawing a sample from the formation into the downhole tool via the inlet by creating a pressure differential. The core may comprise a bladder configured to take a shape of the inner cavity when filled. The compliant outer cover may form the entire outer surface of the packer and may prevent the core from contacting the wellbore or borehole wall. The downhole tool may be configured for conveyance in a borehole via at least one of a wireline or a drillstring or any other conveyance.

The present disclosure also introduces an apparatus comprising: a base plate having an aperture configured to receive an inlet in fluid communication with a downhole tool; an outer cover extending from a peripheral portion of the base plate and having a first surface forming a first portion of an outer surface of a packer and configured to engage a borehole wall and a second surface forming an inner cavity; a first core having a first surface forming a second portion of the outer surface of the packer and configured to engage the borehole wall, a second surface engaging the second surface of the outer cover forming the inner cavity, and a third surface adjacent a first portion of the inlet; and a second core disposed between the first core and the base plate. The base plate may form the inner cavity with the second surface. The second core may have a first surface engaging the second surface of the outer cover forming the inner cavity and a second surface adjacent a second portion of the inlet. The outer cover may comprise a first material, the first core may comprise a second material, and the second core may comprise a third material, and the second and third materials may be more compliant than the first material. The first core may comprise a sealing material and the second core may comprise a bladder. The apparatus may further comprise one or more reinforcement strands disposed between the first and second surfaces of the outer cover. The outer cover may be composed of about 85 durometer material and at least one of the first and second cores may be composed of about 65 durometer material. The outer cover may be composed of about 85 durometer material, the first core may be composed of about 75 durometer material, and the second core may be composed of about 65 durometer material. The downhole tool may be configured for conveyance in a borehole via at least one of a wireline or a drillstring.

The present disclosure also introduces an apparatus comprising: a base plate having a first aperture configured to receive an inlet in fluid communication with a downhole tool; a compliant outer cover having a first end terminating at the base plate and a second end terminating adjacent a forward opening of the inlet, the compliant outer cover having a first surface configured to engage a borehole wall and a second surface forming an inner cavity with the base plate; and a core disposed within the inner cavity and having a second aperture configured to receive at least a portion of the inlet, wherein the compliant outer cover comprises a first material and the core comprises a second material more compliant than the first material. The core may abut the second surface of the compliant outer cover, the base plate and a probe barrel defining the inlet. A first surface of the core may have a curvature substantially similar to a curvature of the second surface of the compliant outer cover. The apparatus may further comprise a support disposed between the first and second surfaces of the compliant outer cover. The support may comprise at least one of a rib or a reinforcing strand. The core may comprise a bladder configured to take a shape of the inner cavity when the bladder is filled. The apparatus may further comprise a second core disposed in the inner cavity and comprising a third material more compliant than the first material of the outer cover. The apparatus may further comprise a metal insert in the compliant outer cover disposed between the first and second surfaces of the compliant outer cover and adjacent the forward opening of the inlet. The core may be composed of a solid material. The first material may be greater than about 80 durometer material and the second material may be less than about 70 durometer material. The downhole tool may be configured for conveyance in a borehole via at least one of a wireline or a drillstring.

The foregoing outlines features of several embodiments so that those skilled in the art may better understand the aspects of the present disclosure. Those skilled in the art should appreciate that they may readily use the present disclosure as a basis for designing or modifying other processes and structures for carrying out the same purposes and/or achieving the same advantages of the embodiments introduced herein. Those skilled in the art should also realize that such equivalent constructions do not depart from the spirit and scope of the present disclosure, and that they may make various changes, substitutions and alterations herein without departing from the spirit and scope of the present disclosure.

The Abstract at the end of this disclosure is provided to comply with 37 C.F.R. §1.72(b) to allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims.

What is claimed is:

1. An apparatus, comprising:

a base plate having an aperture configured to receive an inlet in fluid communication with a downhole tool;

an outer cover extending from a peripheral portion of the base plate and having a first surface forming a first portion of an outer surface of a packer and configured to engage a borehole wall and a second surface forming an inner cavity;

a first core having a first surface forming a second portion of the outer surface of the packer and configured to engage the borehole wall, a second surface engaging the second surface of the outer cover forming the inner cavity, and a third surface adjacent a first portion of the inlet; and

a second core disposed between the first core and the base plate;

wherein the first core comprises a sealing material and the second core comprises a bladder.

2. The apparatus of claim **1** wherein the base plate forms the inner cavity with the second surface.

3. The apparatus of claim **1** wherein the second core has a first surface engaging the second surface of the outer cover forming the inner cavity and a second surface adjacent a second portion of the inlet.

4. The apparatus of claim **1** wherein the outer cover comprises a first material, the first core comprises a second material, and the second core comprises a third material, and wherein the second and third materials are more compliant than the first material.

5. The apparatus of claim 1 further comprising one or more reinforcement strands disposed between the first and second surfaces of the outer cover.

6. The apparatus of claim 1 wherein the outer cover is composed of about 85 durometer material and at least one of the first and second cores is composed of about 65 durometer material.

7. The apparatus of claim 1 wherein the outer cover is composed of about 85 durometer material, the first core is composed of about 75 durometer material, and the second core is composed of about 65 durometer material.

8. The apparatus of claim 1 wherein the downhole tool is configured for conveyance in a borehole via at least one of a wireline or a drillstring.

9. The apparatus of claim 1 wherein the bladder is filled with a fluid.

10. An apparatus, comprising:

a base plate having a first aperture configured to receive an inlet in fluid communication with a downhole tool;

a compliant outer cover having a first end terminating at the base plate, the compliant outer cover having a first surface configured to engage a borehole wall and a second surface forming an inner cavity with the base plate; and

a core disposed within the inner cavity and having a second aperture configured to receive at least a portion of the inlet, wherein the compliant outer cover comprises a first material and the core comprises a second material more compliant than the first material;

wherein the core comprises a bladder configured to take a shape of the inner cavity when the bladder is filled.

11. The apparatus of claim 10 wherein the core abuts the second surface of the compliant outer cover, the base plate and a probe barrel defining the inlet.

12. The apparatus of claim 10 wherein a first surface of the core has a curvature substantially similar to a curvature of the second surface of the compliant outer cover.

13. The apparatus of claim 10 further comprising a support disposed between the first and second surfaces of the compliant outer cover.

14. The apparatus of claim 13 wherein the support comprises at least one of a rib or a reinforcing strand.

15. The apparatus of claim 10 further comprising a second core disposed in the inner cavity and comprising a third material more compliant than the first material of the outer cover.

16. The apparatus of claim 15 wherein the second core comprises an outer surface configured to engage the borehole wall.

17. The apparatus of claim 10 further comprising a metal insert in the compliant outer cover disposed between the first and second surfaces of the compliant outer cover and adjacent the forward opening of the inlet.

18. The apparatus of claim 10 wherein the first material is greater than about 80 durometer material and the second material is less than about 70 durometer material.

19. The apparatus of claim 10 wherein the downhole tool is configured for conveyance in a borehole via at least one of a wireline or a drillstring.

20. The apparatus of claim 10 wherein the compliant outer cover comprises a second end terminating adjacent a forward opening of the inlet and abutting the inlet.

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